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Inaba et al.

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(54) **IN-VEHICLE ELECTRONIC CONTROL UNIT**

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(51) **Int. Cl.**

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H05K 7/14	(2006.01)
H05K 5/02	(2006.01)
H05K 9/00	(2006.01)
H01F 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H05K 7/1427*** (2013.01); ***H01F 5/00*** (2013.01); ***H05K 5/0204*** (2013.01); ***H05K 9/0049*** (2013.01)

(58) **Field of Classification Search**

USPC 361/752, 748, 736

See application file for complete search history.

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Primary Examiner — Andargie M Aychillhum

(57) **ABSTRACT**

An in-vehicle electronic control unit includes a circuit board equipped with a coil and a power supply circuit, a resin member covering the circuit board, and a metal bracket fixed to the resin member for attaching the circuit board to a vehicle. The metal bracket includes a first shield portion and a second shield portion. The first shield portion is arranged to only a part of an upper surface of the resin member so that when projected in a winding axis direction of the coil, the first shield portion overlaps at least a part of the coil. The second shield portion extends from the first shield portion in the winding axis direction of the coil and is arranged to only a part of a side surface of the resin member.

6 Claims, 5 Drawing Sheets

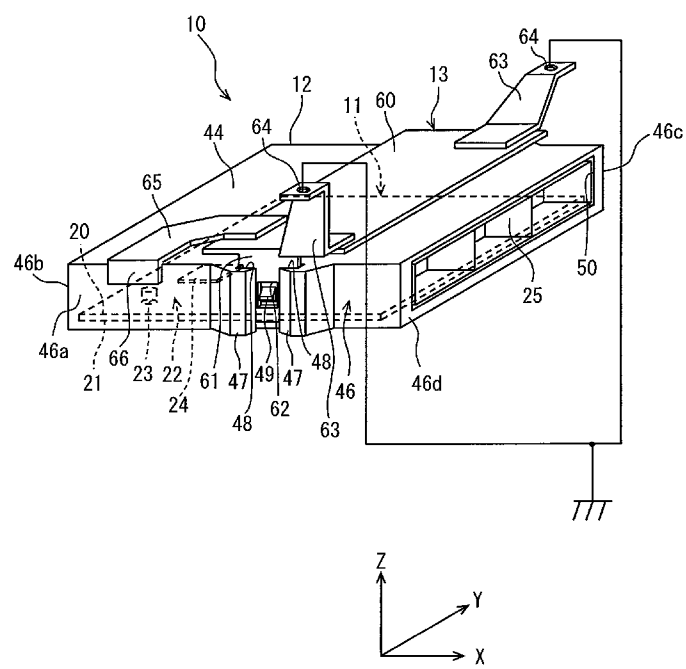
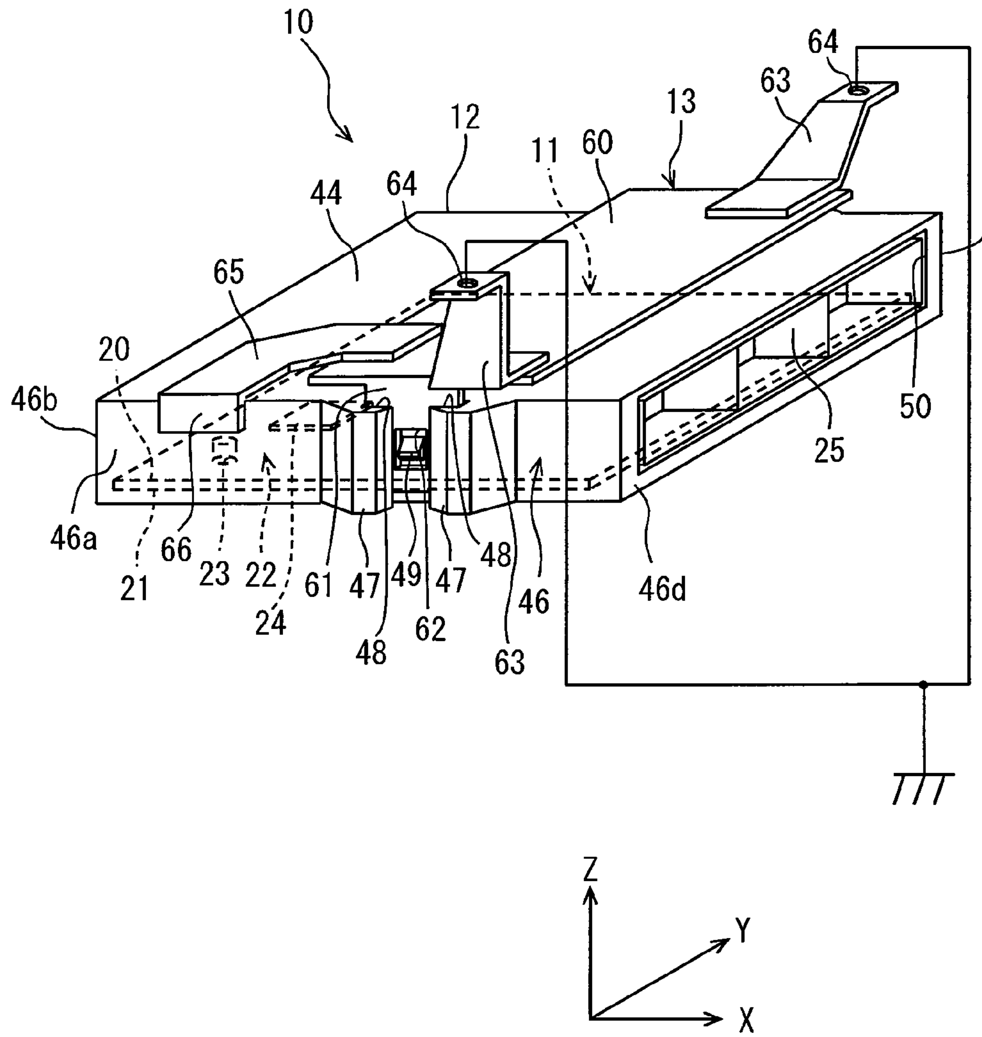


FIG. 1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12
13
64
63
11
60
46c
44
64
65
20
46b
46a
66
23
22
21
24
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47
48
49
62
47
48
63
46
46d
25
50
Z
Y
X

FIG. 2

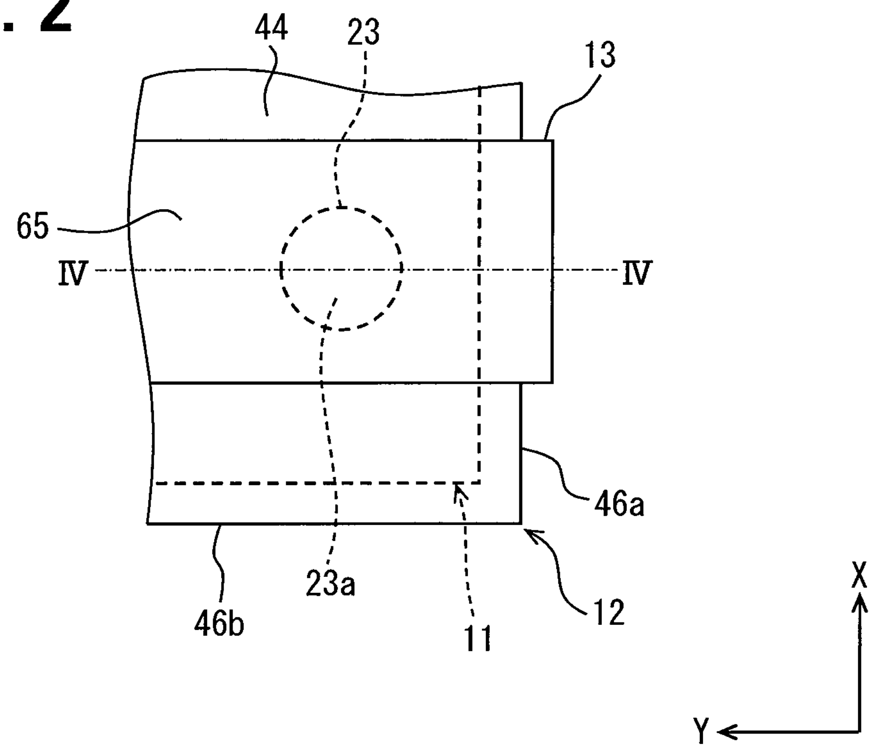

44
23
13
65
IV
IV
46a
46b
23a
11
12
X
Y

FIG. 3

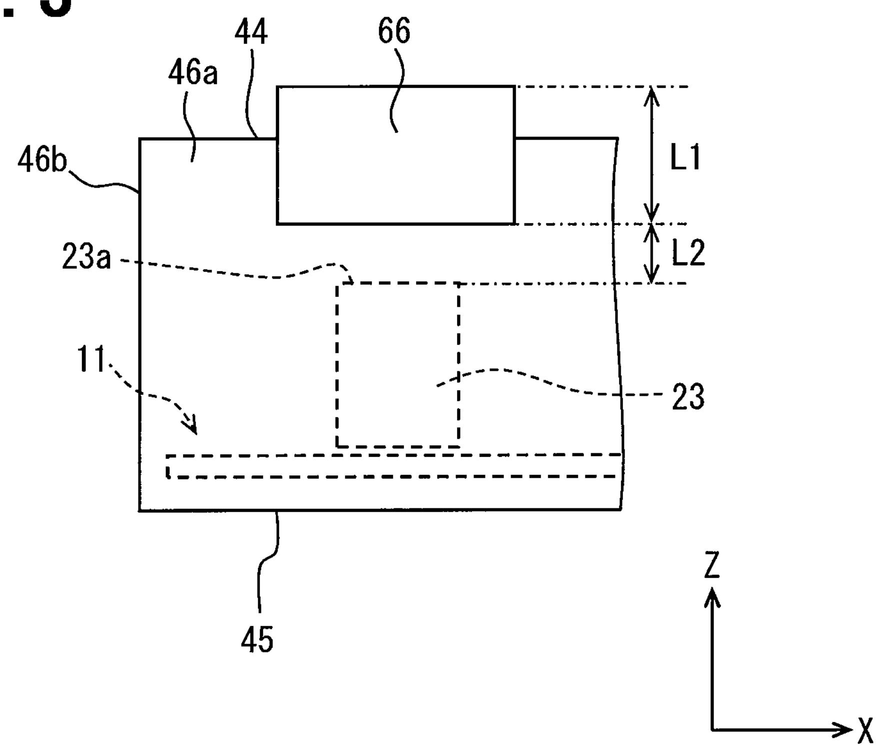

44
66
46a
46b
L1
L2
23a
11
23
45
Z
X

FIG. 4

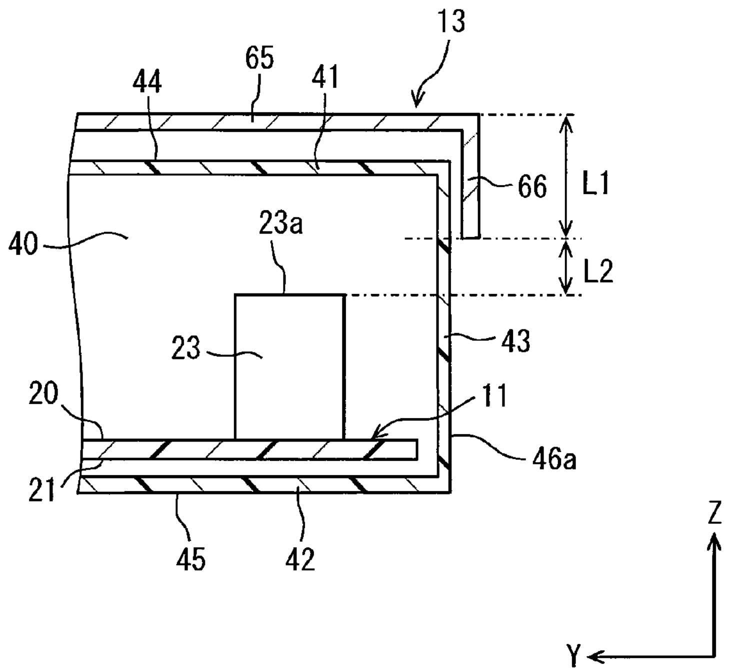
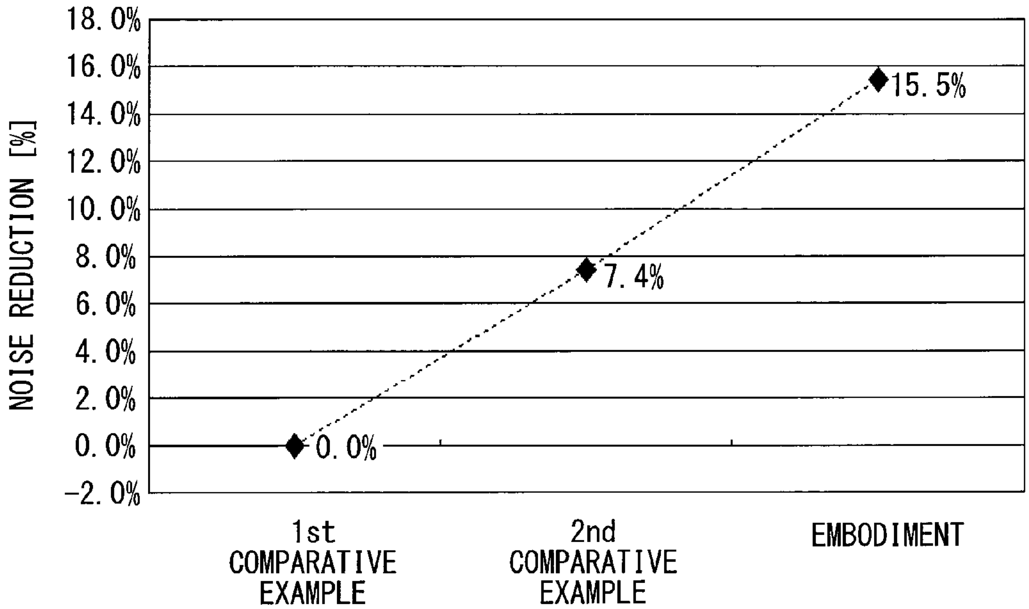

13
65
44
41
66
L1
L2
40
23a
23
43
20
11
46a
21
45
42
Z
Y

FIG. 5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16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
-2.0%
NOISE REDUCTION [%]
15.5%
7.4%
0.0%
1st COMPARATIVE EXAMPLE
2nd COMPARATIVE EXAMPLE
EMBODIMENT

FIG. 6

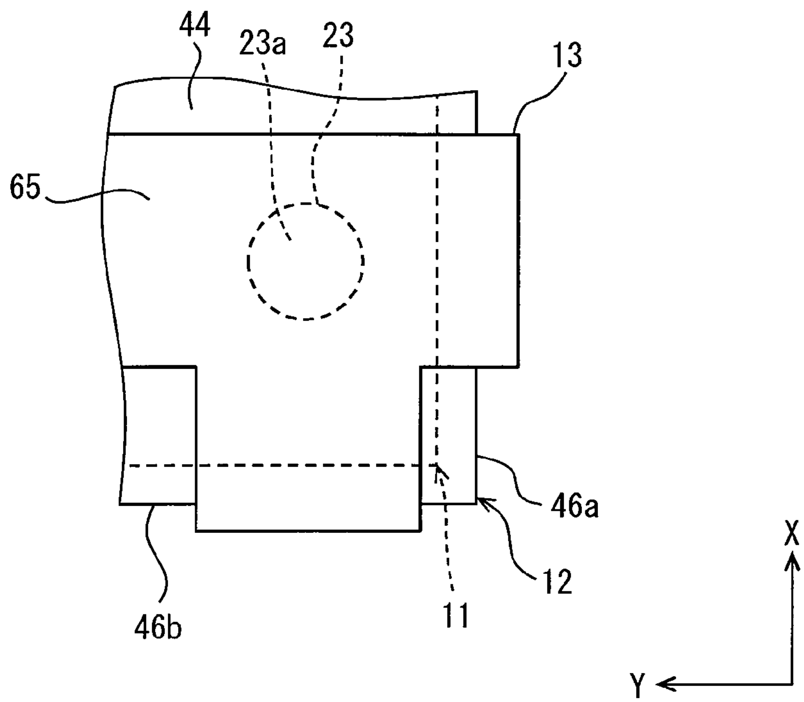

44
23a
23
13
65
46a
12
11
46b
X
Y

FIG. 7

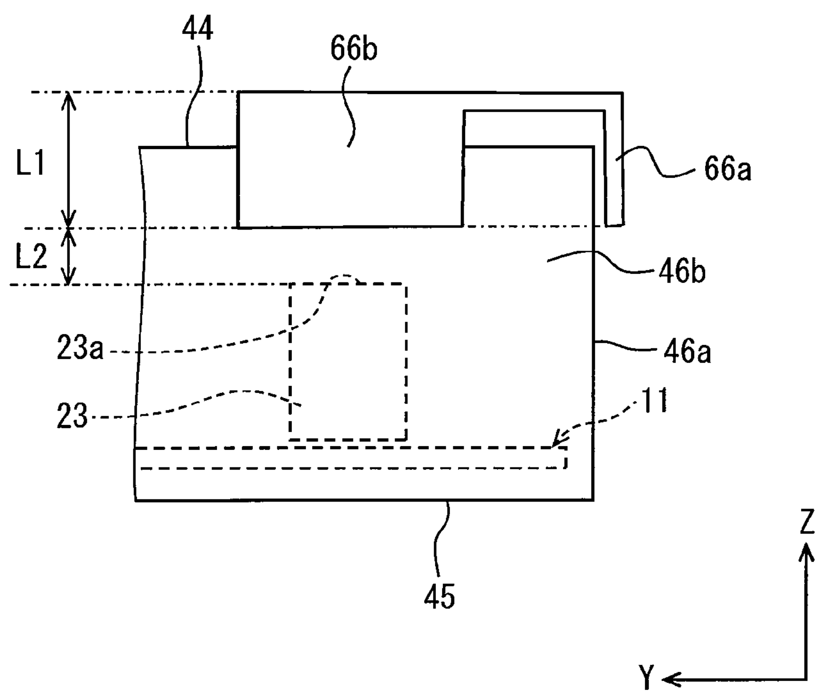
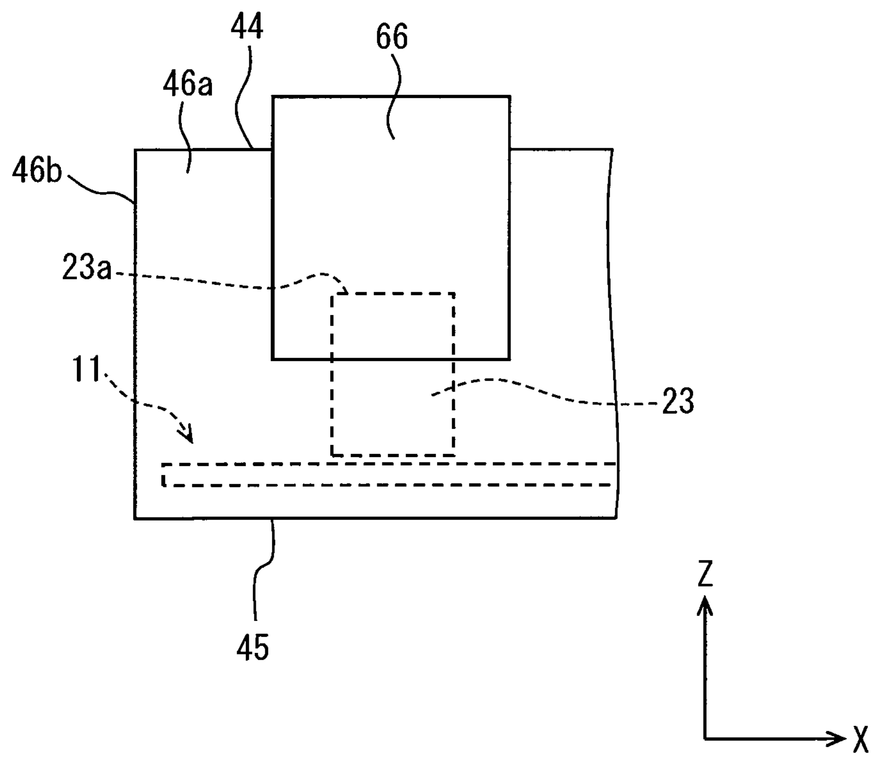

44
66b
L1
66a
L2
46b
23a
46a
11
23
45
Z
Y

FIG. 8



IN-VEHICLE ELECTRONIC CONTROL UNIT

CROSS REFERENCE TO RELATED APPLICATION

The present application is based on Japanese Patent Application No. 2014-250184 filed on Dec. 10, 2014, disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to an in-vehicle electronic control unit including a circuit board and a resin member. The circuit board is equipped with a power supply circuit for performing voltage conversion and mounted with a coil constituting the power supply circuit. The resin member covers the circuit board to protect the circuit board.

BACKGROUND

There is known an in-vehicle electronic control unit including a circuit board and a resin member. The circuit board is equipped with a power supply circuit for performing voltage conversion and mounted with a coil constituting the power supply circuit. The resin member covers the circuit board to protect the circuit board. The resin member is a case which is pre-formed or a molded resin body which is formed to seal the circuit board. Via a bracket fixed to the resin member, the in-vehicle electronic control unit of this kind is attached to a vehicle.

In this in-vehicle electronic control unit, because the circuit board is covered with the resin member, AM band radiation noise generated by the coil is radiated to an outside of the in-vehicle electronic control unit and may be superimposed on an AM radio signal. That is, the radiation noise is superimposed on a radio of the vehicle.

JP2002-9478A corresponding to US2001/0053070A discloses a structure in which electronic parts mounted on a circuit board are covered with an electromagnetic wave shield plate made of metal. When this structure is employed, the level of radiation noise radiated to the outside can be reduced while the circuit board is covered with a resin member.

However, when the structure described in JP2002-9478A corresponding to US2001/0053070A is employed, the number of parts of the in-vehicle electronic control unit increases.

Incidentally, it is conceivable to reduce the level of radiation noise radiated to the outside by employing a metal case in place of the resin member. However, this increases the weight of the in-vehicle electronic control unit and increases the cost.

SUMMARY

It is an object of the present disclosure to provide an in-vehicle electronic control unit that can reduce the number of parts and radiation noise and can suppress a weight increase.

In an aspect of the present disclosure, an in-vehicle electronic control unit comprises a circuit board, a resin member and a metal bracket. The circuit board has a front surface and a rear surface opposite to the front surface. The circuit board is equipped with a power supply circuit that performs voltage conversion. A coil constituting the power supply circuit is mounted on the front surface of the circuit board. The resin member covers the circuit board to protect

the circuit board. An outer surface of the resin member has an upper surface and a lower surface opposite to the upper surface. The upper surface of the resin member is located on a front surface side of the circuit board and the lower surface of the resin member is located on a rear surface side of the circuit board. The resin member further has a side surface that connects the upper surface and the lower surface. The metal bracket is provided for attaching the circuit board to a vehicle and is fixed to the resin member. The metal bracket includes a first shield portion and a second shield portion. The first shield portion is arranged to only a part of the upper surface of the resin member so that when projected in a winding axis direction of the coil, the first shield portion overlaps at least a part of the coil. The second shield portion extends from the first shield portion in the winding axis direction of the coil and is arranged to only a part of the side surface of the resin member. The metal bracket is to be electrically connected to a body of the vehicle.

According to the above in-vehicle electronic control unit, the metal bracket can function as an electromagnetic shield. Specifically, mainly by reflection loss resulting from mismatching of intrinsic impedances and attenuation loss resulting from skin effects, spacial conduction of radiation noise can be cut off. Because not only the first shield portion is arranged in the winding axis direction, i.e., arranged to the upper surface of the resin member but also the second shield portion is arranged to the side surface of the resin member, the radiation nose can be efficiently reduced. This is revealed by the inventors of the present application.

Moreover, because the metal bracket is to be connected to the body of the vehicle, i.e., connected to ground which is stable, the metal bracket can function as an antenna and radiation of noise from the metal bracket can be reduced. This also can reduce the radiation noise.

Moreover, the above technical effects can be achieved by arranging the first shield portion to only a part of the upper surface of the resin member and arranging the second shield portion to only a part of the side surface of the resin member. Therefore, in addition to reducing the radiation noise, it is possible to reduce the weight as compared with a structure in which a metal case is employed in place of the resin member.

Moreover, because the metal bracket for fixing the in-vehicle electronic control unit to the vehicle is used as an electromagnetic shield, it is possible to reduce the number of parts of the in-vehicle electronic control unit in addition to reducing the radiation noise.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present disclosure will become more apparent from the below-described detailed description made with reference to the accompanying drawings, in which:

FIG. **1** is a schematic perspective view illustrating a structure of an electronic control unit of a first embodiment;

FIG. **2** is a top view illustrating a structure around a first shield portion of the electronic control unit of the first embodiment;

FIG. **3** is a side view illustrating a structure around a second shield portion of the electronic control unit of the first embodiment;

FIG. **4** is a sectional view taken along line IV-IV in FIG. **2**;

FIG. **5** is a graph illustrating noise reduction effects;

FIG. **6** is a top view illustrating a structure around a first shield portion of an electronic control unit of a second embodiment;

FIG. **7** is a side view illustrating a structure around a second shield portion of the electronic control unit of the second embodiment; and

FIG. **8** is a side view illustrating a structure around a second shield portion of an electronic control unit of a first modification.

DETAILED DESCRIPTION

Embodiments will be described with reference to drawings. In the below description, like references are used to refer to like parts. A z-direction is a winding axis direction of a coil, where the coil constitutes a power supply circuit in a circuit board. A y-direction is a direction perpendicular to the z-direction. An x-direction is a direction perpendicular to both the z-direction and the y-direction. A planer shape is a shape in an x-y plane, unless otherwise specified.

First Embodiment

A structure of an electronic control unit of the present embodiment will be described based on FIGS. **1** to **4**.

An electronic control unit **10** illustrated in FIG. **1** is mounted to a vehicle and corresponds to an in-vehicle electronic control unit. In the present embodiment, the electronic control unit **10** is configured as an engine ECU (electronic control unit).

As shown in FIGS. **1** to **4**, the electronic control unit **10** includes a circuit board **11**, a case **12**, and a metal bracket **13**. Among these, the case **12** corresponds to a resin member.

In the circuit board **11**, electronic parts are mounted to so called a printed circuit board and a circuit is formed. In the printed circuit board, an electrically insulating substrate such as a resin substrate, a ceramic substrate or the like has wirings. The circuit board **11** has a front surface **20** (also called one surface) and a rear surface **21** opposite to the front surface **20** in the z-direction.

The circuit of the circuit board **11** includes a power supply circuit **22**, as shown in FIG. **1**. This power supply circuit **22** acts as a switching power supply, which performs voltage conversion by at least one of step-up or step-down. As shown in FIG. **4**, a coil **23** and an IC chip **24** are mounted on the front surface **20** of the circuit board **11**. The coil **23** constitutes the power supply circuit **22**. Specifically, the coil **23** constitutes a smoothing circuit of the switching power supply. The winding axis of the coil **23** and the z-direction match with each other. The IC chip **24** includes a switch, a control circuit for controlling the switch, and the like.

A connector **25** is mounted to the circuit board **11**. A part of the connector **25** is exposed from the case **12** to an outside, as shown in FIG. **1**. Accordingly, via the connector **25**, the circuit formed in the circuit board **11** is electrically connectable to other electrical equipment than the electronic control unit **10**.

The case **12** is made of a resin material. The case **12** covers the circuit board **11** in order to protect the circuit board **11**. Before this case **12** covers the circuit board **11**, the case **12** is formed to have an interior space **40**. The circuit board **11** is accommodated in this interior space **40**. Specifically, as shown in FIG. **4**, the case **12** includes a upper wall portion **41** located on a front surface **20** side of the circuit board **11** (i.e., located on an opposite side of the circuit board **11** from the rear surface **21**), a bottom wall portion **42** located on a rear surface side of the circuit board **11** (i.e., located on an opposite side of the circuit board **11** from the front surface **20**), and a side wall portion **43** connecting the upper wall portion **41** and the bottom wall portion **42**. These upper wall portion **41**, bottom wall portion **42** and side wall portion **43** define the interior space **40**.

The case **12** may have what is called an upper-lower-separable structure, in which a part including the upper wall portion **41** and a part including the bottom wall portion **42** are separable. Alternatively, the case **12** may have what is called a bag structure, in which one of the side wall portions **43** is attachable to and detachable from the other portions of the case **12**. In the present embodiment, an upper end surface **23***a* of the coil **23** is not in contact with an inner surface of the upper wall portion **41**, so that the upper end surface **23***a* and the upper wall portion **41** have a space therebetween. In the above, the upper end surface **23***a* of the coil **23** is on an opposite side of the coil **23** from the front surface **20** of the circuit board **11**. The inner surface is a surface exposed to the interior space **40**.

The upper wall portion **41** has an upper surface **44**, which is opposite to the inner surface. The upper surface **44** is a part of an outer surface of the case **12**. The bottom wall portion **42** has a lower surface **45**, which is opposite to an inner surface of the bottom wall portion **42**. The side wall portion **43** has a side surface **46**, which is opposite to an inner surface of the side wall portion **43**.

In the present embodiment, the case **12** has substantially a rectangular shape as its planer shape. Specifically, the case **12** has a rectangular parallelopiped shape. Thus, the case **12** has four side surfaces **46**. Among the four side surfaces **46**, a first side surface **46***a* and a third side surface **46***c* are opposite to each other, and a second side surface **46***b* and a fourth side surface **46***d* are opposite to each other. The first side surface **46***a* and the third side surface **46***c* are substantially parallel to a z-x plane. The second side surface **46***b* and the fourth side surface **46***d* are substantially parallel to a y-z plane. Among the four side surfaces **46**, the first side surface **46***a* is closest to the coil **23**.

The first side surface **46***a* has two protrusions **47** near the center of the first side surface **46***a* in the x-direction. The two protrusions **47** are spaced apart by a predetermined interval in the x-direction. In the z-direction, each protrusion **47** extends from one end to the other end of the first side surface **46***a*. Each protrusion **47** is provided with a groove **48**. The grooves **48**, respectively, are formed in facing surfaces of base portions of the two protrusions **47**. The facing surfaces of the two protrusions **47** are surfaces that face each other. The grooves **48** is formed along the z-direction. In the z-direction, the groove **48** opens at least toward the upper surface **44** from the protrusion **47**. One protrusion **47** is symmetric (mirror symmetric) to the other protrusion **47** with respect to the y-z plane. One groove **48** is symmetric (mirror symmetric) to the other groove **48** with respect to the y-z plane. Specifically, the pair of the one protrusion **47** and the one groove **48** is symmetric (mirror symmetric) to the pair of the other protrusion **47** and the other groove **48** with respect to the y-z plane. To the groove **48**, the below-described press-fitting fixation portion **61** is press-fitted.

The first side surface **46***a* has an engagement protrusion **49** between the two protrusions **47**. The engagement protrusion **49** is at around a z-direction center of the first side surface **46***a*. The third side surface **46***c* has protrusions **47**, grooves **48** and an engagement protrusion **49** as is the case in the first side surface **46***a*.

The side wall portion **43** defining the fourth side surface **46***d* has an opening **50** for exposing the connector **25**.

Because of this, one end of a terminal (not shown) of the connector **25** is exposed to an outside.

The metal bracket **13** is a metal member for attaching the circuit board **11** accommodated in the case **12** to the vehicle (not shown). The metal bracket **13** is fixed to the case **12**. A manner for fixing to the case **12** is not specifically limited. For example, in the present embodiment, the metal bracket **13** is fixed to the case **12** by press-fitting.

The metal bracket **13** includes a base **60**. The base **60** is arranged to the upper surface **44**. The base **60** is a flat plate and has a rectangular shape as its planer shape. The base **60** faces only a part of the upper surface **44**. The base **60** is supported in a floating state relative to the upper surface **44**. In other words, the base **60** is arranged above the upper surface **44** so that the base **60** is not in contact with the upper surface **44**.

The base **60** is arranged over a region from one end of the upper surface **44** to the other end of the upper surface **44** in the y-direction. The one and other ends of the base **60** are connected to the press-fitting fixation portions **61**, respectively. The press-fitting fixation portions **61** are integrated with the base **60**. In other words, the press-fitting fixation portions **61** and the base **60** constitute a single body. The press-fitting fixation portion **61** is bent with respect to the base **60** and extends in the z-direction. The press-fitting fixation portion **61** is press-fitted to the groove **48** of the case **12**. The press-fitting fixation portion **61** has a through-hole **62** for engaging with an engagement protrusion **49**. Among the metal bracket **13**, only the press-fitting fixation portion **61** is in contact with the case **12**. This prevents the following; portions of the metal bracket **13** other than the press-fitting fixation portion **61** contacts with the case **12** due to, for example, vehicle vibrations and unusual sounds or the like are generated.

The base **60** is further connected to an arm portion **63**. In the present embodiment, the arm portion **63** is connected to a specific surface of the base **60** by, for example, welding. The specific surface is opposite to a facing surface of the base **60** which faces the upper surface **44**. Two arm portions **63**, respectively, are connected to opposite ends of the base **60**. Each arm portion **63** has substantially a crank shape that extends away from the upper surface **44** in the z-direction and extends to an outside of the case **12** in the y-direction. Around a tip of the arm portion **63**, the arm portion **63** has a screw hole **64** for attachment to the vehicle. In the present embodiment, the metal bracket **13** is fixed to a body of the vehicle by screwing with the screw hole **64**. This electrically connects the metal bracket **13** to the body of the vehicle.

The base **60** is further connected to a first shield portion **65**. The first shield portion **65** is connected to the base **60** by, for example, welding. The first shield portion **65** is arranged to the upper surface **44** of the case **12** as is the case in the base **60**. The first shield portion **65** is a flat plate having substantially an L-shape. The first shield portion **65** faces only a part of the upper surface **44**. A portion being a combination of the first shield portion **65** and the base **60** faces a part of the upper surface **44**. The first shield portion **65** is supported in a floating state relative to the upper surface **44**.

The first shield portion **65** is arranged so that when projected in the z-direction, the first shield portion **65** overlaps at least a part of the coil **23**. As shown in FIG. **2**, in the present embodiment, a width of the first shield portion **65** (length in the x-direction) is larger than a diameter of an outer boundary of the coil **23**. The first shield portion **65** is arranged so as to overlap the whole of the coil **23** when projected in the z-direction.

A second shield portion **66** is connected to an end of the first shield portion **65**. The second shield portion **66** and the base **60**, respectively, are connected to opposite ends of the base **60**. The second shield portion **66** is integrated with the first shield portion **65**. In other words, the he second shield portion **66** and the first shield portion **65** constitute a single body. The second shield portion **66** is bent with respect to the first shield portion **65** and extends in the z-direction. As shown in FIG. **3**, the second shield portion **66** faces only a part of the side surface **46**. The second shield portion **66** is supported in a floating state relative to the side surface **46**.

In the present embodiment, the second shield portion **66** is arranged to only the first side surface **46*a*** among the multiple side surfaces **46**. It is noted that the first side surface **46*a*** is closest to the coil **23** among the multiple side surfaces **46**. The second shield portion **66** faces only a part of the first side surface **46*a***. In the embodiments, a distance between each side surface **46** and the coil **23** is defined as a distance from the side surface **46** to the winding axis of the coil **23** in a direction perpendicular to the side surface **46**.

When projected in the y-direction perpendicular to the first side surface **46*a*,** the second shield portion **66** extends in the z-direction so that that the second shield portion **66** and the upper end surface **23*a*** of the coil **23** have a gap therebetween. Specifically, as shown in FIGS. **3** and **4**, a length L**2** of the gap is substantially equal to or less than a length L**1** of the second shield portion **66**, where the length L**1** is a length of the second shield portion **66** in the z-direction. For example, the length L**1** of the second shield portion **66** may be 10 mm and the length L**2** of the gap may be in a range between 5 mm and 10 mm.

The second shield portion **66** is arranged so that in a direction parallel to the first side surface **46*a*** (for which the second shield portion **66** is arranged) and perpendicular to the z-direction, i.e., in the x-direction, the position of the second shield portion **66** at least in part matches with the position of the coil **23**. In the present embodiment, a width of the second shield portion **66** (length in the x-direction) is longer than the diameter of the outer boundary of the coil **23**. As shown in FIG. **3**, the second shield portion **66** is arranged so that in the x-direction, coordinate points occupied by the second shield portion **66** contain coordinate points occupied by the coil **23**.

Technical effects of the above electronic control unit **10** will be described.

In the present embodiment, the metal bracket **13** includes the first shield portion **65** for reducing AM band radiation noise emitted by the coil **23**. The first shield portion **65** is arranged to only a part of the upper surface **44** so that when projected in the x-direction which matchers with the winding axis direction of the coil **23**, the first shield portion **65** overlaps at least a part of the coil **23**. Additionally, in the present embodiment, the metal bracket **13** further includes the second shield portion **66** for reducing the radiation noise. The second shield portion **66** is arranged to only a part of the side surface **46**.

In this structure, each shield portion **65**, **66** of the metal bracket **13** functions as an electromagnetic shield. Specifically, spacial conduction of the radiation noise can be cut off mainly by reflection loss resulting from mismatching of intrinsic impedance of space with intrinsic impedance of each shield portion **65**, **66** and attenuation loss resulting from skin effect. Accordingly, the radiation nose can be reduced. In particular, because of the presence of the second shield portion **66** in addition to the first shield portion **65**, the radiation noise can be efficiently reduced as compared with a structure in which only the first shield portion **65** is present.

Moreover, because the metal bracket **13** is connected to the body of the vehicle, i.e., connected to ground which is stable, the metal bracket **13** functions as an antenna and radiation of noise from the metal bracket **13** can be reduced. This also can reduce the radiation noise.

FIG. **5** shows results of actual measurements conducted by the inventors of the present application. The inventors of the present application used a step-down power supply circuit driven at 400 kHz and measured the strength of AM band radiation noise with an electric field antenna. During the measurement, the metal bracket **13** was electrically connected to the body of the vehicle. In FIG. **5**, embodiment refers to a result of the measurement with the structure described in the present embodiment. The measurements were conducted with a structure not having the first and second shield portions and with a structure having only the first shield portion. In FIG. **5**, first comparative example refers to a result of the measurement with the structure not having the first and second shield portions. Second comparative example refers to a result of the measurement with the structure having only the first shield portion. The results of the measurements in the second comparative example and the embodiment relative to the result of the measurement in the first comparative example are shown for the noise reduction effect (%).

FIG. **5** clearly shows that the structure of the present embodiment can efficiently reduce the radiation noise as compared with the first comparative example which does not have the first and second shield portions. It is also clear that the structure of the present embodiment can efficiently reduce the radiation noise as compared with the second comparative example which has only the first shield portion. Specifically, the structure of the present embodiment can reduce the radiation noise by about ten dB to several ten dB, as compared with the first comparative example.

As described above, in the present embodiment, though the first shield portion **65** is arranged to only a part of the upper surface **44** of the case and the second shield portion **66** is arranged to only a part of the side surface **46** of the case **12**, the radiation noise can be efficiently reduced. Therefore, in addition to reducing the radiation noise, it is possible to reduce the weight as compared with a structure in which a metal case is employed in place of the resin case **12**. Additionally, as compared with the metal case, it is possible reduce the cost.

Moreover, because the metal bracket **13** for fixing the electronic control unit **10** to the vehicle is used as an electromagnetic shield, it is possible to reduce the number of parts of the electronic control unit **10** in addition to reducing the radiation noise.

In the present embodiment, the second shield portion **66** is arranged to extend in the z-direction so that when projected in the y-direction perpendicular to the first side surface **46***a,* the second shield portion **66** and the upper end surface **23***a* of the coil **23** have a gap therebetween. Even when the extension length of the second shield portion **66** is arranged to be short in this way, the radiation noise can be efficiently reduced. This can further reduce the weight while efficiently reducing the radiation noise. It is noted that embodiment in FIG. **5** refers to the result of the measurement with the structure, in which the length of the second shield portion **66** is arranged to be short to produce the gap between the second shield portion **66** and the upper end surface **23***a* of the coil **23**. That is, the technical effect of the short second shield portion **66** was also confirmed in the actual measurement.

Moreover, in the present embodiment, the second shield portion **66** is arranged so that in the x-direction, the position of the second shield portion **66** and the position of the coil **23** match with each other at least in part. Specifically, the second shield portion **66** is positioned at a specific portion of the side surface **46** (first side surface **46***a*) to which the second shield portion **66** is arranged, where the specific portion is a portion close to the coil **23** among the side surface **46** (first side surface **46***a*). When the second shield portion **66** is close to the coil **23** in this way, the reduction of the radiation noise can be enhanced.

Moreover, the second shield portion **66** is arranged to the first side surface **46***a* which is closest to the coil **23** among the multiple side surfaces **46**. When the second shield portion **66** is close to the coil **23** in this way, the second shield portion **66** can enhance the reduction of the radiation noise. It is noted that embodiment in FIG. **5** refers to the result of the measurement with the structure taking into account these arrangements.

Second Embodiment

A second embodiment will be described below, in which parts of the electronic control unit common to the first embodiment may be not described in detail.

In the present embodiment, the second shield portion is arranged to not only the first side surface **46***a* but also the second side surface **46***b* among the multiple side surfaces **46**.

As shown in FIGS. **6** and **7**, the metal bracket **13** includes second shield portions **66***a,* **66***b.* The second shield portion **66***a* has the same structure as the second shield portion **66** of the first embodiment. Specifically, the second shield portion **66***a* is arranged to the first side surface **46***a,* which is closest to the coil **23** among the side surfaces **46**. Additionally, the second shield portion **66***a* is arranged to extend in the z-direction so that when projected in the y-direction perpendicular to the first side surface **46***a,* the second shield portion **66***a* and the upper end surface **23***a* of the coil **23** have a gap therebetween. Additionally, the second shield portion **66***a* is arranged so that in the x-direction parallel to the first side surface **46***a* and perpendicular to the z-direction, the position of the second shield portion **66***a* and the position of the coil **23** matches with each other at least in part.

The second shield portion **66***b* is bent with respect to the first shield portion **65** and extends in the z-direction, like the second shield portion **66***a*. The second shield portion **66***b* is arranged to the second side surface **46***b,* which is the second-closest to the coil **23** among the side surfaces **46**. The arrangement of the second shield portion **66***b* relative to the second side surface **46***b* and the coil **23** is the same as the arrangement of the second shield portion **66***a* (the second shield portion **66**) relative to the first side surface **46***a* and the coil **23**

Specifically, the second shield portion **66***b* is supported in a floating state relative to the second side surface **46***b.* Additionally, as shown in FIG. **7**, the second shield portion **66***b* is arranged to extend in the z-direction so that when projected in the x-direction perpendicular to the second side surface **46***b,* the second shield portion **66***b* and the upper end surface **23***a* of the coil **23** have a gap therebetween. Specifically, the length L**2** of the gap is substantially equal to or less than the length L**1** of the second shield portion **66***b.* Furthermore, the second shield portion **66***b* is arranged so that in the y-direction parallel to the second side surface **46***b* and perpendicular to the z-direction, the position of the second shield portion **66***b* and the position of the coil **23** matches with each other at least in part.

In the above-mentioned structure, because the second shield portion **66***b* arranged to the second side surface **46***b* is added, the radiation noise can be reduced as compared with the structure in which the second shield portion **66** is arranged to only the first side surface **46***a.*

In employing this structure, it may be preferable that the coil **23** be positioned near any one of four corners of the circuit board **11**, which has the rectangular shape as its planer shape. Accordingly, the two side surfaces **46***a,* **46***b* are close to the coil **23** and the two second shield portions **66***a,* **66***b* can efficiently reduce the radiation noise.

Although the first and second embodiments have been illustrated, embodiments are not limited to the respective embodiments illustrated above. The above embodiments can be extended and/or modified in various ways, examples of which will be described.

The above embodiments illustrate the engine ECU as an example of the electronic control unit **10**. However, the electronic control unit **10** is not limited to the engine ECU. The electronic control unit **10** may be any in-vehicle electronic control unit as long as the in-vehicle electronic control unit includes a coil **23** and a power supply circuit **22** which performs voltage conversion.

Arrangements of the first shield portion **65** and the second shield portion **66** are not limited to those illustrated in the above embodiments. It may suffice that the first shield portion **65** is arranged to only a part of the upper surface **44** of the case **12** such that when projected in the z-direction which matches with the winding axis direction of the coil **23**, the first shield portion **65** overlaps at least a part of the coil **23**. It may suffice that the second shield portion **66** extends from the first shield portion **65** in the z-direction and is arranged to only a part of the side surface **46**.

In the above embodiments, the first shield portion **65** is arranged so that when projected in the z-direction, i.e., the winding axis direction of the coil **23**, the first shield portion **65** overlaps the whole of the coil **23**. Alternatively, the first shield portion **65** may be arranged to overlap only a part of the coil **23**. When the first shield portion **65** is arranged to overlap at least a part of the coil **23**, the first shield portion **65** is close to the coil **23**, and thus, the reduction of the radiation noise by the reflection loss and the attenuation loss can be enhanced. In this regard, it may be preferable that the first shield portion **65** overlap the whole of the coil **23**.

In the first embodiment, the second shield portion **66** is arranged to extend in the z-direction so that when projected in the y-direction perpendicular to the corresponding first side surface **46***a,* the second shield portion **66** and the upper end surface **23***a* of the coil **23** have a gap therebetween. Alternatively, in a first modification illustrated in FIG. **8**, the second shield portion **66** may be arranged to extend in the z-direction so that when projected in the y-direction perpendicular to the corresponding first side surface **46***a,* the second shield portion **66** overlaps at least a part of the coil **23**. In this regard, when the length of the second shield portion **66** is decreased to form a gap between the second shield portion **66** and the upper end surface **23***a* of the coil **23**, it is also possible to efficiently reduce the radiation noise. Therefore, if the technical effect is sufficiently ensured even when the length of the second shield portion **66** is decreased to form a gap between the second shield portion **66** and the upper end surface **23***a* of the coil **23**, the weight reduction of the electronic control unit **10** can be achieved by making the length of the second shield portion **66** shorter. These are applicable to the structure of the second embodiment.

In the first embodiment, the x-direction is perpendicular to the z-direction and parallel to the first side surface **46***a* to which the second shield portion **66** is arranged. The second shield portion **66** is arranged so that in the x-direction, the position of the second shield portion **66** and the coil **23** match with each other at least in part. Alternatively, the second shield portion **66** may be arranged so that in the x-direction, the position of the second shield portion **66** and the coil **23** do not match with each other. In other words, the second shield portion **66** may be arranged so that in the x-direction, the second shield portion **66** and the coil **23** are spaced apart from each other. This is applicable to the structure of the second embodiment.

In the above embodiments, the case **12** has the rectangular shape as its planar shape. In the first embodiment, the second shield portion **66** is arranged to the first side surface **46***a,* which is closest to the coil **23** among the four side surfaces **46** of the case **12**. In the second embodiment, the second shield portions **66***a* and **66***b,* respectively, are arranged to the first side surface **46***a* closest to the coil **23** and the second side surface **46***b* next closest to the coil **23** among the four side surfaces **46**. However, the arrangement of the second shield portion **66** is not limited to the above examples. It may be suffice that the second shield portion **66** be arranged to only a part of the side surfaces **46**. For example, the second shield portion **66** may be arranged to only the side surface **46** that is the third-closest side surface. In this regard, as the second shield portion **66** is closer to the coil **23**, the reflection loss and the attenuation loss are larger.

The planer shape of the case **12** is not limited to a rectangular shape. The planer shape of the case **12** may be a polygonal shape. In this case also, the same technical effects can be achieved as in the case of the rectangular shape. The planer shape of the case **12** may be other than the polygonal shape. For example, the planer shape of the case **12** may be a circular shape.

In the above embodiments, a material of the metal bracket **13** is not specifically described. In this regard, as along as the metal bracket **13** is made of metal, the above technical effects can be achieved. For example, when the metal bracket **13** is made of a non-magnetic material such as Cu etc., the above technical effects can be achieved. However, when the metal bracket **13** is made of a magnetic material such as Fe etc., the reduction of the radiation noise can be enhanced. Specifically, when the metal bracket **13** (shield portion **65**, **66**) made of a magnetic material is used, the metal bracket **13** further functions as a magnetic shield. More specifically, lines of magnetic force are guided into each shield portion **65**, **66** for bypassing. This can further reduce the radiation noise. Moreover, a magnetic material has high magnetic permeability. Because the attenuation loss is proportional to the square root of the magnetic permeability, the radiation noise can be further reduced.

In the above embodiments, the metal bracket **13** is fixed to the case **12** by press-fitting. However, a fixing manner is not limited to this example. For example, the metal bracket **13** is fixed to the case **12** by screwing.

In the above embodiments, the pre-formed (pre-prepared) case **12** is illustrated as a resin member covering the circuit board **11**. In this case, the resin member may be molded together with the circuit board **11**. For example, a mold resin body may be molded with the metal bracket **13** being an insert part. The metal bracket **13** may fixed to the mold resin body by press-fitting.

What is claimed is:

1. An in-vehicle electronic control unit comprising:

a circuit board having a front surface and a rear surface opposite to the front surface and equipped with a power supply circuit that performs voltage conversion, wherein a coil constituting the power supply circuit is mounted on the front surface of the circuit board;

a resin member covering the circuit board to protect the circuit board, wherein an outer surface of the resin member has an upper surface and a lower surface opposite to the upper surface, wherein the upper surface of the resin member is located on a front surface side of the circuit board and the lower surface of the resin member is located on a rear surface side of the circuit board, wherein the outer surface of the resin member further has a side surface that connects the upper surface and the lower surface; and

a metal bracket for attaching the circuit board to a vehicle, wherein the metal bracket is fixed to the resin member,

wherein the metal bracket includes:

a first shield portion arranged to only a part of the upper surface of the resin member so that when projected in a winding axis direction of the coil, the first shield portion overlaps at least a part of the coil; and

a second shield portion extending from the first shield portion in the winding axis direction of the coil and arranged to only a part of the side surface of the resin member,

wherein the metal bracket is to be electrically connected to a body of the vehicle.

2. The in-vehicle electronic control unit according to claim **1**, wherein

when projected in the winding axis direction of the coil, the first shield portion overlaps a whole of the coil.

3. The in-vehicle electronic control unit according to claim **1**, wherein:

the coil has an upper end surface on an opposite side from the front surface of the circuit board; and

the second shield portion is arranged to extend in the winding axis direction of the coil so that when projected in a direction perpendicular to the winding axis direction of the coil, the second shield portion and the upper end surface of the coil have a gap therebetween.

4. The in-vehicle electronic control unit according to claim **1**, wherein:

the resin member is polygonal in a plane perpendicular to the winding axis direction of the coil;

the side surface to which the second shield portion is arranged is one of a plurality of side surfaces of the resin member; and

in a direction perpendicular to the winding axis direction of the coil and parallel to the one of the plurality of side surfaces of the resin member, a position of the second shield portion and a position of the coil match with each other at least in part.

5. The in-vehicle electronic control unit according to claim **1**, wherein:

the resin member is polygonal in a plane perpendicular to the winding axis direction of the coil; and

the side surface to which the second shield portion is arranged is one of a plurality of side surfaces of the resin member and is closest to the coil among the plurality of side surfaces.

6. The in-vehicle electronic control unit according to claim **1**, wherein

the metal bracket is made of a magnetic material.

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